Mental Imagery Practice as a Therapy for Naming Impairments: A Preliminary Study

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SUMMARY

Anomia remains one of the most recalcitrant linguistic disruptions in aphasia to treat. Developing successful interventions to address the word-finding deficits are complicated by the post-stroke symptom variability and inconsistent recovery patterns associated with anomia. Most of the current treatment methods, with a focus on specific compensating techniques and the repetitive practice of a limited set of items, have had variable success in naming treatment. However, it has not been possible to predict the gains in generalizing the learning beyond the stimuli used in practice or the controlled clinical setting. In this preliminary case study, we explore the value of a novel treatment concept, grounded in centuries of cognitive-perceptual exercises in mindfulness training. It incorporates the practice of mental imagery and focused attention to remedy the broken phonological assembly patterns found in word finding deficits. The aim of this study was to evaluate the potential effectiveness of practicing the repeated activation of mental imagery of concrete objects as a therapeutic tool for repairing disorders of lexical retrieval in a subject with chronic moderate to severe word-finding deficits.

Case study: This trial treatment was used to assist a right-handed, 68-year old educated male with a two-and-a-half years post-onset chronic severe aphasia (anomic type) secondary to a left hemispheric infarct. Two five-week long training protocols involving common (typical) and uncommon (less typical) categories of pictured objects were used for treating anomia. The first trial involved the blocked presentation of stimuli; the second trial, undertaken a year after, included a random presentation of stimuli. It was found that the impact was manifested in three ways: (1) an improved verbal naming of the treated objects; (2) retention of therapeutic gains by a successful generalization to untreated similar lexical items; and (3) importantly, serendipitous gains in the ability to concurrently write the names of the pictured objects. The post-treatment data on all blocked lexical trials, and some random lexical trials, were found to be significant on the Fisher’s exact test.

The use of the visual mental imagery-based therapy had a positive impact on the partial restoration of the subject’s naming.

Key words: Anomia, errorful and errorless learning, mental imagery practice, neuroplasticity.
INTRODUCTION

The lexicon has a well-defined linguistic structure with modules in the mental dictionary for its semantic specificity and phonological form, with provision for connectivity to its storage (Goodglass, 1993; Kay, Lesser, & Coltheart, 2007; Laine & Martin, 2006). Nonetheless, the treatment of word-finding deficits has been an ongoing challenge. Over the years, specific treatment approaches have been used to selectively target the semantic organization of lexicon and the retrieval of its phonological representation. However, the treatment of naming deficits has not always been successful in terms of achieving a broad restorative impact on the lexical abilities of subjects with aphasia. In general, most existing methods of naming treatment have reported clinical gains from therapy. These gains mostly involved improvement in the limited context of the practiced stimuli in the clinical setting (Boyle, 2004; Kiran, 2007; Laine & Martin, 2006; Shewan & Bandura, 1986).

Naming treatments

Many therapeutic concepts have been integrated in treating naming deficits, the most residual symptoms of aphasia. A few representative approaches are discussed in this paper.

Using the paradigm of typical (common) and atypical (less common) words representing various categories of concrete words (Clark & Clark, 1977; Rosch, 1975), Kiran and colleagues reported a stimuli-specific directionality in improved naming of practiced stimuli (Kiran, 2007; Kiran & Basestto, 2008; Kiran & Thompson, 2003). They reported that training atypical words, which are remotely related to the central semantic features of the lexical entities, leads to improved naming skill and its greater generalization. This naming improvement was suggested to have resulted from the activation of a wider and more complex lexical semantic network associated with atypical words. Another semantically based treatment involved the manipulation of the functional features—for example: use, action, location, and word association. This treatment approach also resulted in the improved picture naming of practiced words and in the maintenance of naming ability in subjects with aphasia (Boyle, 1989, 2004; Boyle & Coelho, 1995). Using a case-grammar paradigm (Fillmore, 1968), Edmonds, Nadeau, & Kiran (2009) reported a positive effect on naming by incorporating a verb-centered therapy for anoma. The verb-based semantic network was used to help retrieve the nouns that related to the verb with roles, such as agency (doer), patient (receiver), and location. This verb-semantics activation assisted the subjects with improved retrieval of the associated nouns. Other successful treatment models have included lexical activation from contextual repetitions, phonological priming, and mass repetition for priming a set of words (Laine & Martin, 2006; Martin, 1996; Martin et al., 2004; Martin, Fink, Laine, & Ayala, 2004; Martin, Fink, Renvall, & Laine, 2006; Wilshire & Saffran, 2005). Semantic and phonological cueing hierarchies have also been used with positive results (Greenwald, Raymer, Richardson, & Rothi,
1995; Linebaugh & Lehner, 1977; Marshall, Neuburger & Philips, 1992; Wambaugh, Cameron, Kalinyak-Fliszar, Nessler, & Wright, 2004). Phoneme-initial cueing and sentence completion are reported to be the two most effective tools for lexical retrieval (Pease & Goodglass, 1978). There is also evidence that broken lexical-phonological connections can be repaired through reading and matching a word with its picture (Boyle, 1989).

In summary, each of these treatment methods has demonstrated some success in the remediation of naming deficits. This improvement, however, the generalization of the treatment effect to other stimuli, beyond those practiced in the controlled environments, has been limited (Davis & Pring, 1991; Kendall et al., 2008; Page & Harnish, 2012).

**Alternate Treatments**

There is a growing interest in identifying new concepts with the potential for recovery, healing, and optimizing the brain’s functioning to restore the impaired higher function. At least some of the concepts relate to harnessing the power of the mind-body relationship and the subconscious brain. The premise of adopting these concepts, which have been validated in their therapeutic value, is that constructs like imagery and mindfulness can elicit mental and even physical responses, identical to the ones caused by drugs and real actions (Khatri 2014; Rankin, 2013; Sheikh, Kunzendorf, & Sheikh, 1996). Indeed, the power of the subconscious brain has been long harnessed to play a positive role in alternative medicine and approaches relying on the “placebo effect” (Bhatnagar et al., 2014; Sheikh, 2003). For example, existing clinical approaches already integrate:

- reticular mediated cortical arousal to synchronize brain activity (Andy and Bhatnagar, 1992; Bhatnagar & Mandybur, 2005);
- mindfulness training (Sheikh, 2003);
- meditation (Goleman & Davidson, 2017);
- positive thinking (Khatri, 2014; Rankin 2013).

The potential benefits of these mind-body control concepts related to the power of the subconscious brain have also drawn the attention of scholars in the fields of modern medicine and rehabilitation (Rankin, 2013; Ratey and Herman, 2013).

Historically, the practice of mental-imagery has been used for thousands of years in non-clinical attempts to alter brain-circuitry through mindfulness training and abstract mentation (Davidson, 2015; Goleman & Davidson, 2017; Sheikh, 2003). As a cognitive construct, mental imagery refers to quasi-perceptual experiences of which we are self-consciously aware. The application of this practice is underpinned by the research findings that the perception of visual imagery and its effects on an individual can approximate the actual experience of exposure even in the absence of the actual stimuli (Richardson, 1969, Sheikh, 2003). Indeed, the cognitively controlled rehearsals of visual and mental representations, have been recognized for their potential contributions in healing, brain conditioning, and in recovery (Page and Harnish 2012; Sheikh, 2003; Thomas, 2008).
The clinical power of mental imagery practice has not yet been fully unlocked but is worth further exploration for its value in rehabilitation. The association of the imagery with a modulated brain’s neural-circuitry has significant implications for the neuroplasticity (Davidson, 2015; Kakigi et al., 2005; Orme-Johnson, Schneider, Son, Nidich, & Cho, 2006; Sheikh, 2003; Zeidan et al., 2011). The therapeutic effectiveness of the practice of mental imagery has been documented in the treatment of a variety of cortically regulated dysfunctions including pain-perception, depression, sleep disorders, hypertension, anxiety, and sensorimotor disorders (Khatri, 2014; Sheikh, 2003). The use of imagery intended to elicit emotions has led to the activation of the previously silent insular region in the brains of those undergoing compassion training (Davidson, 2000, 2008, 2015; Davidson and Lutz, 2008). There are many functional and physiological attributes that lend credence to potentially productive use of mental imagery practice in rehabilitation and recovery:

- it is a well-recognized healing concept across numerous cultures over centuries (Sheikh, 2003);
- the same mental schemata are active in the brain each time an associated concept or a movement is merely thought of (Arbib, 2006);
- the identical brain regions fire whether an actual movement is undertaken or whether the movement schema is thought about or seen (Keysers, 2010);
- the conceptual images are distinctively served by each hemisphere (Bisach & Berti, 1990) and they remain undisturbed, even after injuries to their localized brain-regions (Sheikh, 2003; Thomas, 2008);
- the strength lies in its concurrent incorporation of all the brain’s networks (Klinger, 1980; Richardson, 1984; Sheikh & Panagiotou, 1975);
- imagery also serves as a constant source of details in episodic memory (Kepecs, 1954; Singer, 1974; Sheikh & Jordan, 1983; Sheikh & Panagiotou, 1975).

Undisturbed imagery power and induced activation of the brain suggest that it is worth it to explore if it can be an effective tool in restoring higher mental function in patients with brain injuries.

**Mental imagery integration in rehabilitation**

The power of the practice of mental imagery has been recognized in the fields of physical and occupational therapies. The awareness of the brain-behavior link, where the same brain region is active whether an action is thought of or is executed, is the force behind the imagery-based training of neuronal circuitry in subjects with brain injuries (Thomas, 2008). This link in some way is reminiscent of the current “mirror neuron theory” (Arbib, 2006; Grezes, Armony, Rowe, & Passingham, 2003; Keysers, 2010). It has been found that the integration of the practice of mental imagery has been more beneficial for muscle retraining than physical-exercise therapy alone (Liu, Chan, Lee, & Hui-Chan, 2004; Page, Levine, & Hill, 2007; Page, Dunning, Hermann, Leonard, & Levine, 2011; Page & Harnish, 2012; Page, Levine, Sisto, & Johnston, 2001). Physical practice, supplemented with mental practice, has been observed to increase functional motor performance and self-perception of improved skills in subjects with brain injuries (Liu, Chan, Lee, & Hui-Chan, 2004; Page, Levine, & Hill, 2007; Page, Dunning, Hermann, Leonard, & Levine, 2011; Page & Harnish, 2012; Page, Levine, Sisto, & Johnston, 2001).
Different lengths of the practice of mental imagery have also led to the reduced physical impairment in hemiplegia (Page et al., 2011). This effect of the imagery practice on brain circuitry has been supported by the observations from motor evoked potential, electroencephalographic activation, and increased cerebral blood flow to the associated cortical areas (Lacourse, Orr, Cramer, & Cohen, 2005; Page et al., 2007).

Additional evidence supporting the practice of imagery has come from occupational therapy, in which its practice resulted not only in the skill impairment reduction, but also in the improved functional recovery of the limbs (Nilsen, Gillen, & Gordon, 2010), and increased skill generalization to novel environments (Liu et al., 2009). Comparing three groups of stroke patients, Dijkerman, Ietswaart, Johnson, & Walter (2004) found that the group that received motor imagery training demonstrated the greatest improvements on strength and skill of movement involving the paralyzed limb.

This rehabilitation and medication-based research have also identified imagery leading to improved cognition in neurological subjects. Liu and colleagues (2004) noted that the mental imagery practice positively impacted attentiveness in subjects with stroke. This practice has also been associated with improved planning and skill execution with improved self-monitoring (Braun, Kleynen, & Schols, 2008; Liu et al., 2004). It has also been associated with brain’s increased creativity (Martindale, 1990).

Similar evidence of improved language processing has existed in neurosurgical literature where the reticular modulated cortical arousal resulted in improved information processing, attentiveness, and recall abilities in subjects with brain injuries (Andy & Bhatnagar, 1992; Bhatnagar & Andy, 1989; Bhatnagar, Andy, Korabic, and Tikofsky, 1990; Bhatnagar & Mandybur, 2005; Ojemann, 1983).

**Mental imagery and speech language rehabilitation**

Despite the substantial physiologically supported clinical evidence discussed earlier in support of the ability of mental imagery practice to improve cognitive processing and retrain brain circuitry, the clinical application of imagery has remained unexplored in speech-language rehabilitation. Indeed, it has not been incorporated as a therapeutic tool in the treatment of language deficits. However, given the evidence that imagery practice can enhance and/or assist in the restoration of brain’s physical and mental functions through retraining of the neural circuitry, such practice ought to be also considered in speech-language therapy to examine whether it can have a similar impact on language processing.

There are only two studies in speech-language rehabilitation that indirectly relate to the theme of this paper. Myers (1980) was perhaps the first to discuss the importance of object imageability in aphasia therapy. In another study, clarity of image through hypnosis was utilized in the treatment of naming disorders in three subjects with Broca’s aphasia (Thompson, Hall, & Sison, 1986). Two of them exhibited improved naming on treated items but only one exhibited some generalization.
Aims

Hoping to take advantage of the neural activation through the dynamics of imagery, this investigation was undertaken (1) to examine if the repetitive activation of the object associated brain’s visual-perceptual circuitry in the temporal-occipital cortices facilitates naming function, (2) to evaluate whether controlling off-target and erroneously spoken responses improves lexical retrieval, and (3) to assess if the controlled imagery practice can have an effect on generalization of the learning beyond the practiced items.

A sub goal was also to examine if the lexical presentation mode of imagery evocation (blocked versus random) interacted differently with the lexical processing.

The naming task was considered as an ideal treatment target for two reasons: first, its deficits can be studied independent of other cooccurring semantic and syntactic symptoms in aphasia; second, any name search task is associated with distinct semantic elements and image activations.

METHODS AND PROCEDURES

Participant

The subject was a right-handed, 68-year old educated male with chronic aphasia, who was two-and a-half years post left hemispheric infarct. MRI showed a subacute infarct involving a large area of the inferior frontal lobe and of the anterior and posterior temporal lobe in addition to the entire insular cortex covering the area of the middle cerebral artery distribution (Figure 1, arrows).

Axial MRI of the brain at the level of lateral ventricles, DWI (1A) and FLAIR (1B) sequences show evidence of restricted diffusion in most of the left middle cerebral artery distribution (arrows). The insular cortex is also involved in its entirety (arrowhead).

Figure 1 A-B. A left hemispheric stroke
A year later, brain imaging showed porencephalic changes with laminar necrosis in the frontal operculum, in the posterior temporal lobe, and necrotic changes in the left anterior insula (Figure 2).

Axial MRI SPGR T1 sequences show porencephalic changes with laminar necrosis in the frontal operculum and the posterior temporal lobe (2A-B, arrows). Cystic necrotic changes are also present in the left anterior insula (arrowheads). The stroke resulted in a right-sided hemiplegia with an oral-facial palsy. Within days of the stroke, the subject was reportedly found to have moderately impaired comprehension, reduced verbal expression, and severely limited naming, reading, and writing functions. An assessment of his language function on the Boston Diagnostic Aphasia Examination (BDAE)-Short Form (Goodglass, Kaplan, & Barresi, 2001) completed two months after the stroke indicated a conduction-type aphasia with severe anomia.

The subject made notable gains in all language (comprehension, repetition, and expression) functions following two-years of speech and language treatment. However, he continued to exhibit a moderate to severe naming deficit; his naming was assessed on the Boston Naming Test-BNT (Kaplan, Goodglass, & Weintraub, 2001). His ability to read and write also remained severely impaired.

With his persistent impaired naming, this subject agreed to participate in our experimental treatment program (approved by the University Human Subject Committee) involving the practice of mental imagery to selectively target his naming impairments.

This investigation was completed in two stages. In the first, this subject practiced the mental imagery for the objects that were presented in a block cycle. In the second study completed a year later, the subject practiced mental imageries for the objects that were presented randomly. During these investigations, the subject did not receive any other formal or informal speech and language treatment.
Study one: stimuli presentation in blocks and training

This investigation phase began two-and-a-half years after the onset of stroke. The test stimuli contained two sets (A and B) of pictured objects. Each set contained ten typical (Robin) and ten atypical (Emu) exemplars taken from four concrete lexical categories: birds, furniture, clothes, and sports (Rosch, 1975), for a total of 80 different pictured objects in each set. The stimuli in set A (experimental set) were used for the training and practice, while the different 80 stimuli in set B, not presented for practice, were used for assessing the potential generalization, if any, of the learning from the imagery-based strategy.

This assessment protocol was like the one previously used for cognitive-com- municative assessment in neurological subjects with deep brain stimulation (Bhatnagar and Mandybur, 2005). The purpose for including the set B stimuli was to separate the generalized effect of the treatment from the practice effect of training on set A from set B.

Repeated testing over three sessions was used for establishing the stable baseline (spoken and written) performance for both sets (A and B) of stimuli prior to the treatment onset (Tables 1 and 2). The best performance (second session) was used as the pre-treatment baseline. The writing response was included in the assessment protocol, as the subject often made a deliberate attempt to supplement his verbal response with an effort to inscribe it. Before the sessions for baseline measures, the subject had received an hour of orientation about the study and the use of mental imagery practice; he was also instructed to suppress any overt verbalization of the stimuli being used in the treatment. The subject and his wife understood the task. After the assessment pretreatment performance, the subject was given the set A stimuli to practice at home. Stimuli from each semantic category were presented to the subject together in a block. A PowerPoint of each target word picture was prepared with recorded instructions on each slide. In the instruction, he was verbally given the object name (e.g. here is a parrot) and was directed to think of the given target image for 60 seconds, while refraining from verbally naming and practicing it sub-vocally, notwithstanding what the mind may do reflexively (Corballis, 2015). The subject reviewed the stimuli in set “A” three-times a day for five weeks. His wife timed and monitored each session; she also maintained a diary of the daily treatment attendance, which revealed a total compliance.

The pre- and post-treatment data was analyzed into four types of responses: (i) correctly spoken only, (ii) correctly written only, (iii) correctly both spoken and written, and (iv) error rate (misnaming, no response, or unrecognized responses). As a measure of an additional control, the subject was also tested before and after the treatment on the BDAE-Short Form (Goodglass et al., 2001) and the BNT (Kaplan et al., 2001). The post-treatment performance on BDAE showed no notable improvement across language functions though there was a minimal improvement on including naming (BNT).

As part of a follow up, the subject was retested on the very stimuli (set A and B) six months after the treatment phase. His naming performance was lower
than his post treatment levels, but it was better than the pre-treatment level of performance.

**Study two: stimuli presentation in random cycle and training**

There has been a discussion that words presented in a block or presented randomly may be processed differently. Thus, semantic errors in naming by subjects with aphasia could represent the interference by the coactivation or over-activation of erroneous or related items that compete with the target (Dell, Martin, & Schwartz, 2007; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997). One way to minimize the interference is to present stimuli in an alternate form (Wheeldon & Monsell, 1994). Therefore, it was decided to explore the mental imagery practice effect on naming through a randomly organized presentation of lexical items (Schnur, Schwartz, Brecher, & Hodgson, 2006). This investigation was undertaken a year after the beginning of the treatment phase with blocked stimuli, which was 42 months after the stroke onset.

This investigation phase again involved the presentation of sets (A and B) of typical and atypical stimuli from the categories (birds, furniture, clothes, and sports) with each set consisting of 80 stimuli; they were different from the ones used in the first study. After explaining the procedures about the use of mental imagery and the avoidance of verbal attempts, repeated testing over three sessions was used for establishing the stable baselines (spoken and written) for both sets of stimuli prior to the onset of training. The best performance (second trial) was used as the baseline for the treatment. A software program was used to generate random cyclic stimuli, mixing all lexical categories for each presentation of a PowerPoint slide with recorded instructions, which contained the recorded object name (Here is the shirt.) and reminded the subject to think of the object image for 60 seconds. The subject had been told not to name it verbally or practice it sub-vocally.

The subject practiced set A stimuli three times a day for five weeks and was retested on both sets (A and B) of stimuli after the treatment phase. Set B stimuli were included to evaluate the generalization of learning, like in the previous trial. The data was analyzed into previously listed four response types. His performance was also measured before and after the treatment on two tests: the BDAE-Short Form (Goodglass et al., 2001) and the BNT (Kaplan et al., 2001). His post treatment performance on these two measures did not show any notable change in his language on the BDAE (Goodglass et al., 2001 and naming functions on the BNT (Kaplan et al., 2001).

As part of a follow up, the subject was retested on the stimuli (set A and B) five months after a treatment phase. His naming performance was lower than his post treatment levels, but it was better than the baseline performance.

**RESULTS**

A comparison of the subject’s pre- and post-treatment performances, displayed as response percentages, revealed positive changes in his naming skill. This
treatment effect applied to all lexical categories across typical and atypical types in both trials- blocked cyclic (Tables 1 and 2) and random cyclic (Tables 3 and 4). The improvement was marked by a reduced number of anomic responses and an improved ability to write the object names across the lexical types and categories. This increased ability to write was an unsuspected observation, as writing was neither targeted nor was promoted in the treatment.

A similar naming improvement was noted on unpracticed (set B) stimuli in both trials: blocked cyclic (Table 2) and random cyclic (Table 4).

This improved performance on unpracticed stimuli in set B reflected a strategy-driven skill that our subject had cognitively used to repair the broken phonological links through mental imagery practice.

The data was analyzed to evaluate the differences in correct response rates in pre- and post-treatment assessments in both studies. The hypothesis was tested to compare the distributions of correct naming responses in spoken-only, written-only, spoken and written both, and misnaming from pre to post perform-

Table 1. Set A (Block) stimuli; pre- and post-treatment performances

<table>
<thead>
<tr>
<th>Typical words</th>
<th>Spoken</th>
<th>Written</th>
<th>Spoken-written</th>
<th>Error rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-tx</td>
<td>7.5%</td>
<td>20%</td>
<td>5%</td>
<td>67.5%</td>
</tr>
<tr>
<td>Post-tx</td>
<td>0%</td>
<td>45%</td>
<td>12.5%</td>
<td>42.5%</td>
</tr>
</tbody>
</table>

P-value = 0.012 *p-value = 0.0122

<table>
<thead>
<tr>
<th>Atypical words</th>
<th>Spoken</th>
<th>Written</th>
<th>Spoken-written</th>
<th>Error rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-tx</td>
<td>5%</td>
<td>17.5%</td>
<td>2.5%</td>
<td>75%</td>
</tr>
<tr>
<td>Post-tx</td>
<td>0%</td>
<td>37.5%</td>
<td>20%</td>
<td>42.5%</td>
</tr>
</tbody>
</table>

P-value = 0.001 *p-value = 0.0016

Table 2. Set B (Block) stimuli; pre- and post-treatment performances

<table>
<thead>
<tr>
<th>Typical words</th>
<th>Spoken</th>
<th>Written</th>
<th>Spoken-written</th>
<th>Error rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-tx</td>
<td>10%</td>
<td>5%</td>
<td>0%</td>
<td>85%</td>
</tr>
<tr>
<td>Post-tx</td>
<td>5%</td>
<td>23%</td>
<td>12.5%</td>
<td>60%</td>
</tr>
</tbody>
</table>

P-value = 0.005 *p-value = 0.0062

<table>
<thead>
<tr>
<th>Atypical words</th>
<th>Spoken</th>
<th>Written</th>
<th>Spoken-written</th>
<th>Error rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-tx</td>
<td>10%</td>
<td>7.5%</td>
<td>0%</td>
<td>83%</td>
</tr>
<tr>
<td>Post-tx</td>
<td>13%</td>
<td>25%</td>
<td>5%</td>
<td>57%</td>
</tr>
</tbody>
</table>

P-value = 0.045 *p-value = 0.0055

Table 3. Set A (Random) stimuli; pre- and post-treatment performances

<table>
<thead>
<tr>
<th>Typical words</th>
<th>Spoken</th>
<th>Written</th>
<th>Spoken-written</th>
<th>Error rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-tx</td>
<td>0%</td>
<td>10%</td>
<td>15%</td>
<td>75%</td>
</tr>
<tr>
<td>Post-tx</td>
<td>0%</td>
<td>30%</td>
<td>22.5%</td>
<td>47.5%</td>
</tr>
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</table>

P-value = 0.031 *p-value = 0.0059

<table>
<thead>
<tr>
<th>Atypical words</th>
<th>Spoken</th>
<th>Written</th>
<th>Spoken-written</th>
<th>Error rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-tx</td>
<td>10%</td>
<td>10%</td>
<td>15%</td>
<td>65%</td>
</tr>
<tr>
<td>Post-tx</td>
<td>10%</td>
<td>30%</td>
<td>10%</td>
<td>50%</td>
</tr>
</tbody>
</table>

P-value = 0.0162 *p-value = 0.0869
ances. With low cell counts in some cases, the Fisher’s exact two-tailed test was considered as the best tool for data analysis with a p-value < 0.05 as being significant. Statistically significant differences were observed for the typical blocked stimuli in both set A (p-value=.012, Table 1) and set B (p-value=.05, Table 2), as well as atypical blocked stimuli for set A (p-value=.001, Table 1) and set B (p-value=.045, Table 2) when compared with baseline performance. Another hypothesis was tested to assess whether error rates improved from pre to post using one-tail z-test. Significant improvements were observed for blocked stimuli in both set A and set B (p-value <0.02, Table 1 and Table 2).

The p-value was also assessed for the second study involving randomly presented stimuli, but statistical significance was found only for typical and atypical stimuli in set A (p-value=.031; p-value=.0162 Table 3) and atypical stimuli for set B (p-value=.001, Table 4) when compared with the baseline performance. A significant improvement was also noted when comparing the error rates (p-value = 0.0059, Table 3). A treatment effect was noted for the typical randomly presented stimuli for set B (Table 4) and also for typical and atypical randomly presented stimuli for set A (Table 4), but this difference was not found to be significant.

**DISCUSSION**

The success of mental imagery practice-based naming treatment in this study highlights three clinical concepts: errorful learning, errorless learning, and neuroplasticity. The naming treatment, where subjects’ verbal responses are replete with semantic and phonological errors and the patient learns from his own errors is referred to as “errorful learning.” The treatment that prevents errors to reinforce the learning is labeled as “errorless learning.” Neuroplasticity is the brain’s built-in capacity to reorganize in order to retain or regain functions in face of injuries.

Traditional treatments for word-finding deficits have been designed to improve access to the target lexicon by reinforcing the association between the concepts of objects and their lexical-phonological representations. This association is linked through multiple cue-based repetitive responses that include a range of verbal efforts. Many of the repetitive attempts can be target-related, but many others are far from the target lexicon, often being labeled as “abstruse.” Some errors may be related to the target by both semantic and phonological resemblance. Eventually, the correct name may or may not be articulated by conduite d’approche,
or worse, by conduite d’ecart. This clinical intervention with “errorful” learning neither prevents verbal errors from occurring nor does it appear sensitive to any potential impact that errors may have on cellular restructuring of an alternative path for partial or fully successful naming. Alternative to this was the method of errorless learning, which had been proven as a superior method for treating patient with amnesia (Baddeleley and Wilson, 1994). However, its superior effectiveness was not found in naming treatment. A review of a series of clinical studies revealed that the outcomes of naming treatments were the same regardless of which error controlling mode (errorful or errorless) was used (Fillingham, Hodgeson, Sage, & Lambon, 2003). In a recent more focused study, both naming treatment methods were again found to be equally effective, though errorless learning was preferred by the participating subjects (Fillingham, Sage, & Lambon 2006). The authors also found that the subjects benefitting from the errorful learning were the ones with a better working memory and attention. This suggests an important role that the prefrontal executive system can play in rehabilitation (Helm-Estabrooks, 2002).

A disapproval of the traditional “trial and error” articulatory treatment method, also known as errorful, comes from the Aristotelian behavioral neuroscience of learning (Buckingham, 2002), which involves the concepts of the synapse formations, synaptic connection strengths, and the neuronal distance involved with the correct or incorrect associative responses. More recently, the Hebbian theory of learning describes synaptic connectivity between two neurons and synaptic efficiency as a neuroanatomical substrate for new learning and memory consolidation (Buonomano & Merzenich, 1998; McClelland, Thomas, McCandless, & Fiez, 1999). Hebb suggests that all behaviors and actions represent neuronal activation and that the cells, which functionally activate together, are the ones that connect. Repeated sequential activation of the connected neurons, as well, enhances the synaptic strength of networked neurons involved with learning and memory. The neuronal restructuring and adaptation during learning and adjusted synaptic efficiency relate to plasticity (Bhatnagar, 2018; Hebb, 1949, 1961; Klein and Jones, 2008; Nudo, 2006). Thus, from a neuronal adaptivity perspective, erroneous and/or off-target responses in errorful learning would form their own real synaptic connections/events, which can become competitive with further chained activations of neurons working together for correct naming. Since the off-target neuronal activations are consistently at variance with the pattern that squares with the target word being sought, this extraneous connectivity can potentially have a deleterious effect on eventually correct naming ability.

Our mental imagery-based observations provide support for the Hebbian (1961) physiology, which goes for non-verbal thought/image processing as well as for pre-motoric processing on the production/movement side of the picture. We consider the practice of mental imagery-based teaching to be in the spirit of errorless learning, since it focuses on strengthening the intact internal lexical representation without the interference potentially posed by any broken phonetic assembly representations. Protecting our subject from undertaking any aberrant
articulatory gestures for naming and associated errorful neuronal connectivity might have facilitated the net improved learning with its successful generalization to untreated stimuli in sets B.

The interesting aspect of this improvement was its cross-modal integration for the learning generalization to word writing, which has been observed as an example of inter-systemic neuroplasticity. This appears to be an indirect and serendipitous generalization to the language network with a type of natural direction, particularly with its closeness to the visual-perceptual graphic mode. This spontaneous visual pathway involvement may have some implications for the brain’s built-in capacity to reorganize for retaining or regaining pre-ictal functions or for rearranging the circuitry (Bhatnagar, 2018, pp 153-155; Buonomano & Merzenich, 1998; Page and Harnish, 2012). The cause for this natural directionality in recovery could be an anatomical one (Restak, 2010, pp 107-108), and/or brain’s homoeostasis, and/or chemical one (Hiroki et al., 2018). Since this improvement occurred two and half-years post-onset of stroke, it raises an issue about the experience specificity or salience for neuroplasticity (Klein and Jones, 2008, Nudo, 2006). Does the brain’s neuroplasticity respond to some forms of treatment parameters better than others, or to all indiscriminate stimulations, or merely to those specifically relevant to learning, as it was previously stated in mirogenetic approach (Brown & Pąchalska 2003; Pachalska et al. 2018). An understanding of this salience, relevance, and specificity will have significant implications for the physical and cognitive rehabilitation after brain injuries.

CONCLUSION

This preliminary data from a single subject with aphasia and clinical evidence from other branches of rehabilitation suggest that cognitively practiced imagery of perceptual impressions retrains brain circuitry, promotes skill restoration, and increases cognitive functions. This imagery-based brain retraining could also be true in case of cognitive-communicative behavior. This practice of a mental imagery-based naming treatment worked as an “errorless” mode of learning. As a cognitive facilitator, the practice of mental imagery contributed to learning and its generalization to untreated stimuli. It is suggested here that by avoiding erroneous verbal responses, our subject prevented the formation of distracting and unwanted neuronal connections associated with broken phonological assembly representations. Of course, our observations are preliminary.

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